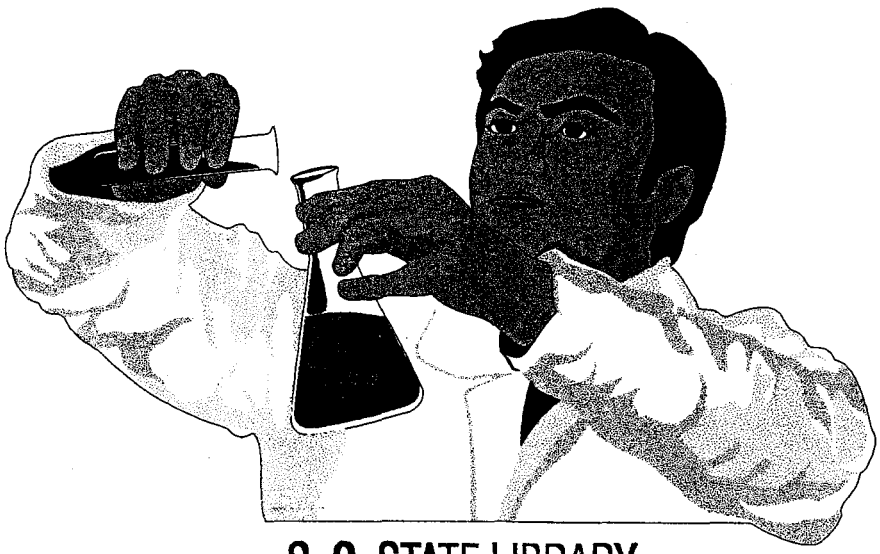
EQC LABORATORY

ANALYTICAL PROBLEMS



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March 19, 1999
Date Submitted

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Signature

EQC LABORATORY
ANALYTICAL PROBLEMS

DHEC's Environmental Quality Control deputy area houses one Central Laboratory and five Regional Laboratories located across the state. They provide analytical support for the various programs within EQC. In addition, they provide services for Health District investigations and the general public. The laboratories are staffed by professional analysts possessing scientific degrees. These analysts are responsible for the daily analyses and processing of environmental samples collected throughout the state.

One of the guiding principles that helps our agency successfully carry out its mission, is the "*use of applied scientific knowledge for decision making.*"[1] Decisions are made every day based on information provided by our laboratories. Our internal and external customers rely on this data to regulate, monitor, and protect the health of the public and the environment. Providing quality lab results in a timely manner is our commitment as we try to meet their expectations.

Our laboratories employ state of the art instrumentation and follow approved procedures and methodologies. Strict quality assurance guidelines are established through our Procedures and Quality Control Manual for Chemistry Laboratories. Adherence to these guidelines is critical to produce valid data.

" *The quality of work required in the laboratories is well defined and each analyst has a basis for establishing pride and confidence in his/her work. The analysts within the laboratory system work cooperatively to produce data which will withstand close scrutiny by members of the Agency, Federal officials, and courts of*

[redacted]

[1]South Carolina Department of Health and Environmental Control, Strategic Plan (August, 1995), p.7.

law."[2] Ideal conditions in the laboratories are realized when samples, analyses, and data reporting, flow smoothly and efficiently, with few interruptions, errors, and analytical problems.

Problem areas that continue to plague our central and regional laboratories are procedural technical difficulties and the analysis of difficult samples. They are inherent to all of our labs. Time lags and errors often result when the analysts are troubleshooting procedures and dealing with analytical problems. The efficiency of the lab suffers and in many instances test results are delayed or become unusable. Repeat sample collection has been necessary and turn around times lengthen. These problems have a definite impact on service delivery. They result in extra work for both our internal and external customers and prolonged waiting periods for the information they need. Lab customers expect accurate and timely data. Meeting that expectation has become increasingly more difficult. FY98 data shows an increase in the number of analytical and instrumental problems experienced over FY97. As these problems grow, ideal conditions in the lab become harder and harder to achieve.

It is the goal of this project to improve lab performance, reduce troubleshooting time, and assist the analysts with technical problems. Input from all of our laboratories will be solicited to decide on the most useful and beneficial information to assist them. A target date of April, 1999 is planned for compilation and distribution of that information. The success and benefits of the project will be measured after one year.

Laboratory documents have been developed by EPA such as their, Technical Notes on Drinking Water Methods, and by EQC's Office of Laboratory Certification entitled, Guidance Document for SCDHEC Personnel Performing Field Parameter Analyses. These documents were " *prepared to add modifications, clarifications, options, or improvements to methods that have been previously approved and*

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[2]Office of Environmental Quality Control, Analytical Services Division, Procedures and Quality Control Manual For Chemistry Laboratories, Vol.I., p.ii.

published."[3] It is hoped the information we compile will function similarly and prove to be just as valuable a resource to our laboratory operation.

The question of why our labs experience frequent analytical problems is still of concern. Possible causes may be inexperience of new staff, clarity of the procedures, or lack of training in resolving problems. Confirming any of these potential causes and others would require more information.

To gather data about our lab staff, insight into problems they are confronted with, and solicit input concerning contributing factors or causes, a questionnaire was developed. It was sent to sixteen analysts representing six laboratories. Both laboratory managers and analysts were included in the survey. Since all of the analysts use the same procedures, they could provide valuable information and would have a vested interest in the best option to provide them technical assistance. Questions dealt with lab experience, training, analytical procedures, identifying problems, contributing factors, and methods to provide assistance. A copy of the questionnaire is included in the appendix. (**See Appendix A**)

Fifteen analysts provided feedback. Focussing first on personnel, problems and contributing factors, results are categorized below: (**See Appendix B**)

1. **Experience and training:**

- ✎ Sixty-seven percent of the analysts have been employed in the lab for more than two years with forty-seven percent holding chemistry degrees.
- ✎ Most initial training was done locally in the lab in which the employee works.
- ✎ Approximately half of the analysts had received training in potential problems they might encounter.

2. **Problems experienced:**

- ✎ Fifty-three percent of analysts experience problems intermittently to

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[3]U.S. Environmental Protection Agency, Office of Water, Technical Notes on Drinking Water Methods, EPA-600/R-94-173 p. iii.

frequently.

- ✎ Fifty-nine percent said the procedures addressed problems they've encountered either partially or poorly.
- ✎ Eighty-seven percent said the procedures could use some clarifying or additional information.
- ✎ Problems experienced the most were instrumental, procedural and sample handling.
- ✎ Staff turn to experienced analysts and other references more often than the S.O.P for assistance with analytical problems

4. Contributing factors to lab problems:

- ✎ Employee turnover
- ✎ Sample loads/bottlenecking/ rushing to process analyses
- ✎ Improperly filled out/confusing sample forms
- ✎ Uncoordinated schedules
- ✎ Interruptions/technical assistance for sampling personnel
- ✎ Poor ergonomics
- ✎ Instrument repairs
- ✎ Improper equipment for the test

Three factors surfaced from the responses that may contribute to how our analysts handle analytical problems. First is the experience of the analysts. One third of our staff have been employed in the lab for less than two years. In fact, five out of six labs have experienced personnel turnover within the past two years. Less than half of the analysts possess chemistry degrees. Due to limited staffing in the regional labs, many of the microbiologists also assist with the chemistry analyses. Having a different background may play a factor in how chemistry problems are handled. Several staff members have never visited another regional lab to train or compare operations. Over fifty percent had limited or no training in potential problems they might face with the procedures during their initial training. Second, the analytical procedures only partially address problems encountered and many need clarifying or

additional information. Our procedures try to take into account interferences and problems that could arise, but as with any method, all situations encountered aren't known and aren't addressed. Third, analysts turn to sources other than our S.O.P. when facing analytical problems. This signals a definite need for an additional method of providing them assistance.

Other factors identified related to sample volume, schedules, program forms, instrument repair, and day to day interruptions in the lab. Since many of these causes are beyond the analyst's control, concentrated efforts to look closer at the number and nature of analytical problems experienced were needed.

For this task, our regional lab managers were asked to generate a summary of lab problems they could document for FY97, FY98, and thus far in FY99. To make sure each lab would report data in the same manner, an operational definition found in our laboratory S.O.P for recording lab errors/problems was used. The **Data Control Recording Notes** are used on the report forms when results can't be reported for a requested parameter. (**See Appendix C**) This helps our customers understand why certain data wasn't included. Each lab would stratify and record the number of samples involved in three classifications, or subgroups of problems experienced. Although five different subgroups are noted on the form, **lab errors, instrument problems, and analytical problems** were the only ones asked to count.[4] Sample collection and transportation problems are beyond the control of the laboratory and were not included. A histogram of the laboratory problems experienced is included in the appendix. (**See Appendix D**)

The histogram confirms that we experience more instrumental and analytical problems than lab errors. It also shows we saw a 60 % increase in instrumental problems and a 148% increase in analytical problems during FY98. Fiscal year 1999 data mainly acknowledges that problems still persist. A closer look into each

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[4]Office of Environmental Quality Control, Analytical Service Division, Procedures and Quality Control Manual For Chemistry Laboratories, Vol. I., Section IV-G, P.1.

problem area will allow further examination into causes.

1. **Lab errors are documented as follows**:
   - ✍ Sample was not analyzed during maximum holding time limit
   - ✍ Sample was discarded by mistake
   - ✍ Sample container was broken in the laboratory
   - ✍ Dilution was missed
   - ✍ Sample improperly preserved in laboratory
   - ✍ Test improperly assigned in laboratory

These errors result mainly from the analysts' handling of the samples. Bottlenecking , sample loads, and rushing to complete analyses may be contributing factors here.

2. **Instrument problems are documented as follows**:
   - ✍ Instrument failure/problem...if holding time is exceeded while instrument is being repaired.

There isn't much the analyst can do to prevent these type of problems. They are special cause situations and are corrected as quickly as possible.

3. **Analytical problems are documented as follows**:
   - ✍ Reagent contaminated and sample cannot be analyzed
   - ✍ Brief instrument or equipment(supplies) malfunction, but no more sample or sample was too old to repeat
   - ✍ Procedure on hold while working out a reagent or instrument problem, or while waiting for new lamp, etc.
   - ✍ Quality control performance problem
   - ✍ Interference..if a definite result is impossible due to matrix interference

Analytical problems are a mixture of special and common causes. If an instrument malfunctions, a probe goes bad, or a reagent becomes contaminated, they are special cause situations that are *unpredictable and temporarily or sporadically disturb the process.* Quality control problems, interferences, and systematic problems are common cause situations that require *stratification, experimentation, and*

disaggregation of the analytical process to improve it.[5] Analysts spend vast amounts of time trying to correct and lessen the recurrence of these type of problems.

To determine the potential impact of these problems on our customers, the labs were asked to estimate the percentage of their total samples they receive from three different program areas. The results were:

93-100% Stream and Facility Monitoring Program

0-5% Public Outreach Program (Private Wells)

0-2% Public Drinking Water Program

It is plain to see that when problems occur, more samples will be affected in our stream and facility monitoring programs. These programs/customers will have a definite interest in how well our labs address problems. **(See Appendix E for Data Flow Chart that displays our lab customer base)**

Ongoing data collection activities are unwarranted. Information gathered from these three efforts have provided enough insight into the causes and effects of analytical problems in the lab. Lessening the impact and offering assistance when problems do occur are the major points on which to focus our attention.

Now that underlying causes of lab problems are better understood, designing an intervention tool to help analysts effectively deal with analytical problems is the next step. Several alternatives to provide assistance were listed in the questionnaire. Ninety-three percent of respondents thought a technical guide would be the most practical and lasting method of providing them assistance when troubleshooting laboratory problems and procedural difficulties. This strategy was selected as the best approach. Topics they wanted to see covered were:

- Procedural problems encountered and solutions implemented
- Technical hints for handling difficult samples/ interferences
- Results of method research studies conducted

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[5]S.C. Budget and Control Board, Office of Human Resources, Center for Education, Quality and Assessment, Principles of Quality, pp. VI-5, VI-15.

- Technical notes concerning the procedures
- Scientific articles related to our procedures and lab operation

A project plan to design and produce the technical guide is included in **Appendix F**. Steps necessary to complete the project are listed with time frames for each step. Resources and supplies are also included in the plan. I will lead the coordination efforts to compile and edit information to be included in the guide. As stakeholders, analysts and lab managers will play active roles in providing input and feedback. A memo will be sent to all analysts informing them of the proposed guide and its purpose. Each will be asked to contribute information on problems experienced and solutions they've implemented. A standardized input form will be developed to allow consistency in format.(**See Appendix G**) Any pertinent articles, references, or information they may have regarding our analytical procedures will also be welcomed. Regional lab managers or appointees will serve as points of contact and a committee for determining contents of the guide. The Director of the Analytical Services Division, the Quality Assurance Manager, and the Regional Laboratory Coordinator will provide final review and approval of all materials included. Communication will take place by e-mail, phone and through our courier service. Meetings to review and discuss the contents will be scheduled as warranted. A target date of April, 1999, for completion and distribution of the guide is planned in conjunction with our annual Spring Laboratory Meeting. The guide's purpose and use will be formally communicated at that time.

It is anticipated the proposed guide will serve many functions. First and foremost, to provide our analysts a reference they can turn to when facing analytical problems and procedural difficulties. Second, to become a training tool for new employees who aren't familiar with the procedures or problems they may encounter. Plans are to have the guide listed as a training aid for new staff in Section III of our Standard Operating Procedures. Third, to serve as a record and acknowledgment of contributions from past and present lab staff. Many have worked diligently on solutions and improvements to make our lab program better. The guide may also

serve as a reference when offering technical assistance to public/private labs and facilities.

As with any project, obstacles may stand in the way of its successful implementation. Receiving timely feedback and submittals from the analysts are two obstacle to be expected. Reminders of deadlines for their contributions and submittals will be sent at several points throughout the process. Other obstacles may be the actual typing and copying of material. These efforts will have to be performed in addition to regular work assignments and will require the commitment of several people. There are no plans to have the guide produced out of house, so costs should be minimal. Purchasing binders, tabs, etc. shouldn't be a problem, but need to be consider in allowing time for ordering and receiving needed materials.

Analysts, lab managers, and administration will all play key roles in making sure any obstacles that arise are addressed. The success of the project will be a joint endeavor and require a team approach to accomplish. The result will be a product our laboratory staff can reference for years to come.

A formal evaluation of the project will take place in April, 2000, after the guide has been in place for one year. Another questionnaire will be sent to the analysts seeking input concerning its use and effectiveness. In October, 1999, a preliminary evaluation will also be conducted. A short polling of the analysts will be performed through e-mail or phone survey. Each evaluation will seek input into the following three areas.

1. **Use**: Are you referencing the guide?
2. **Contents**: Is it meeting your needs?
3. **Improvement**: Has the troubleshooting time dealing with problems been reduced?

Results of the evaluations will be used to modify the guide as necessary. Opportunities will exist for regular updates as new suggestions and findings warrant. Analysts will be encouraged to experiment and research better ways to deal with analytical problems as they ocurr.

Feedback received will be incorporated into revising/updating the guide to better serve the user. It is the intent that it become a dynamic document. Open communication with lab managers and staff will be instrumental in assuring the guide's continued use. As new analytical problems surface, their inclusion will offer the analysts ongoing support. A potential barrier to overcome will be maintaining and keeping the guide current. Hopefully, this task will be adopted by those who acknowledge it's usefullness and will work to keep it viable.

The success of the project will be realized if the guide helps the analysts address technical problems, reduce troubleshooting times, and improve lab performance. This in turn will increase both the analytical quality and service delivery to our customers. By accomplishing these objectives, the guide should exemplify another of our agency's values: *"We are committed to meeting or exceeding customers' identified needs and expectations with quality service."*[6]

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[6]South Carolina Department of Health and Enviornmental Control, Strategic Plan, (August, 1995), p.3.

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Environmental Protection Agency, Office of Water, Technical Notes on Drinking Water Methods, EPA-600/R-94-173 (October, 1994).

South Carolina Budget and Control Board, Center for Education, Quality and Assessment, Principles of Quality.

South Carolina Budget and Control Board, Center for Education, Quality and Assessment, The Manager's Role in Planning.

APPENDIX A

EQC LABORATORY QUESTIONNAIRE
OCTOBER, 1998

Please take a few moments to complete the following questionnaire . Base your responses on your personal experiences and perceptions of our analytical program. You do not have to identify yourself.

1. How long have you been employed by the EQC laboratory program?
   A. Less than two years.
   B. Between two and ten years.
   C. More than ten years.

2. What is the scientific discipline in which you hold a degree?
   A. Chemistry
   B. Biology
   C. Microbiology
   D. Other

3. Are you an analyst or in laboratory management?
   A. Analyst B. Analyst /Laboratory Manager

4. What type of initial lab training did you receive upon being hired?
   A. Training at the Central laboratory.
   B. Training at a Regional laboratory.
   C. Localized training by another laboratory staff member.
   D. None of the above. Training was done independently.

5. Did the initial training cover potential problems you might encounter with procedures, samples, and processes in the lab?
   A. No, this area was not covered.
   B. Some, but very limited due to the time allotted for training.
   C. Yes, I was made aware of many of the analytical problems I might encounter.

6. How would you rate the clarity of our current chemistry procedures used in the regional and central labs?
   A. Very clear and straightforward with no need for additional information.
   B. Straightforward, but could use a little clarifying or additional information.
   C. Several of the procedures need clarifying to make them easier to use.
   D. The procedures are unclear and difficult to follow.

7. Have you experienced analytical problems that required you to spend time troubleshooting the chemistry procedures, instruments, or processes in the lab?
   A. Yes, frequently.
   B. Yes, intermittently.
   C. Yes, but very seldom.
   D. No, I haven't run across a problem yet.

8. How well do the procedures address analytical problems you encounter?
   A. Thoroughly B. Satisfactorily C. Partially D. Poorly

APPENDIX A

9. How would you classify lab problems/errors that occur most frequently. Choose top three.
   A. Handling of samples; (discarded, broken, mixed up, holding times)
   B. Instrument problems (repairs, calibrations, operational difficulties)
   C. Procedural problems (systematic, contamination, interferences, etc.)
   D. Quality control problems (duplicate and spike data out of limit)

10. What other factors besides those listed in question (9) do you feel contribute to time lags and problems/errors (inefficiencies) in the lab?

    _____

    _____

    _____

11. Where do you seek assistance the most when faced with analytical problems in the lab?
    A. I refer to our procedures manual for guidance. (S.O.P.)
    B. I reference other books such as Standard Methods, EPA, or Instrument manuals.
    C. I seek the advise and suggestions of another experienced analyst.
    D. I go to my supervisor or technical director.

12. What would be the most practical and lasting method of providing all analysts assistance when troubleshooting laboratory problems and procedural difficulties?
    A. Hands on assistance when problems occur.
    B. Phone call or e-mail assistance as needed.
    C. A listing of analytical references to consult.
    D. A procedural technical guide that listed specific problems encountered and solutions implemented that have been effective in similar situations.
    E. Other:_____

13. If a technical guide was developed, what would you like to see included?
    A. Procedural problems and solutions.
    B. Study results involving our procedures.
    C. Technical hints for handling difficult samples.
    D. Scientific articles related to our laboratory program.
    E. Circled above and other:

       _____

       _____

       _____

       _____

Thank you for taking the time to complete this questionnaire. Information gathered will be used in developing training aids and tools to assist lab personnel when dealing with analytical problems.

Return the completed questionnaire in the blue, inter-office, confidential envelope to:

Jimmy Owens, Lab Mgr.
Pee Dee EQC Office
Florence, S.C. 29506 Phone: 843-661-4825

APPENDIX B

EQC LABORATORY QUESTIONNAIRE RESULTS , OCTOBER'98

Question	Response (A)	Response (B)	Response (C)	Response (D)	Other information
1. How long with EQC lab program?	5	6	4		
2. What scientific degree?	7	6	0	2	
3. Analyst or Mgr.?	9	6			
4. Initial lab training?	6	5	7	1	
5. Potential problems covered?	3	5	7		
6. Clarity of procedures?	0	13	2	0	
7. Have you experienced problems?	1	7	5	2	
8. Do the procedures address problems?	0	6	5	4	
9. Classify problems?	10	12	10	9	
10. Other factors that contribute to problems?	Employee turnover, heavy sample load; improper sample collection	training of monitoring staff, don't have proper equip.	Paperwork errors, rushing due to time of delivery of samples	bottlenecking, uncoordinated schedules, technical assistance to others	inexperience of staff, interruptions for assistance, schedule changes, poor ergonomics, confusing sample forms
11. Where do you seek assistance?	5	4	5	3	
12. Most practical method of assistance?	1	0	0	14	
13. What would you like included in a technical guide?	11	3	12	4	interferences; technical notes on procedures; ref. to articles about our procedures
Additional input:	more organized training; trainee rotate to other labs	share info about problems and how solved with everyone	mathematical equations are difficult to understand/follow at times	share sample load during training of new employee	

APPENDIX C

Data Control Recording Notes

Please use the following notation on the appropriate report form when no results can be reported for a requested parameter. This notation should also be recorded in the workbook or data printout, e.g., Lab Error - Sample Container broken in the laboratory.

1. Lab Error

   A. Sample was not analyzed during maximum holding time limit (See Section IV-B for recording procedure)
   B. Sample was discarded by mistake
   C. Sample container was broken in the laboratory
   D. Dilution was missed (report "greater than" value whenever possible)
   E. Sample improperly preserved in laboratory
   F. Test improperly assigned in laboratory

2. Instrument failure/problem...if holding time is exceeded while instrument is being repaired

3. Analytical Problem

   A. Reagent contaminated and sample cannot be analyzed
   B. Brief instrument or equipment (supplies) malfunction, but no more sample or sample was too old to repeat
   C. Procedure on hold while working out a reagent or instrument problem, or while waiting for new reagent, lamp, etc.
   D. Quality Control Performance Problem
   E. Interference...if a definite result is impossible due to matrix interference

4. Sample collection problem

   A. Sample collected in improper container
   B. Suspected sample contamination
   C. Sample improperly preserved in the field
   D. Sample over holding time when received in the lab
   E. Insufficient sample received

5. Sample Transportation Problem
   A. Courier error

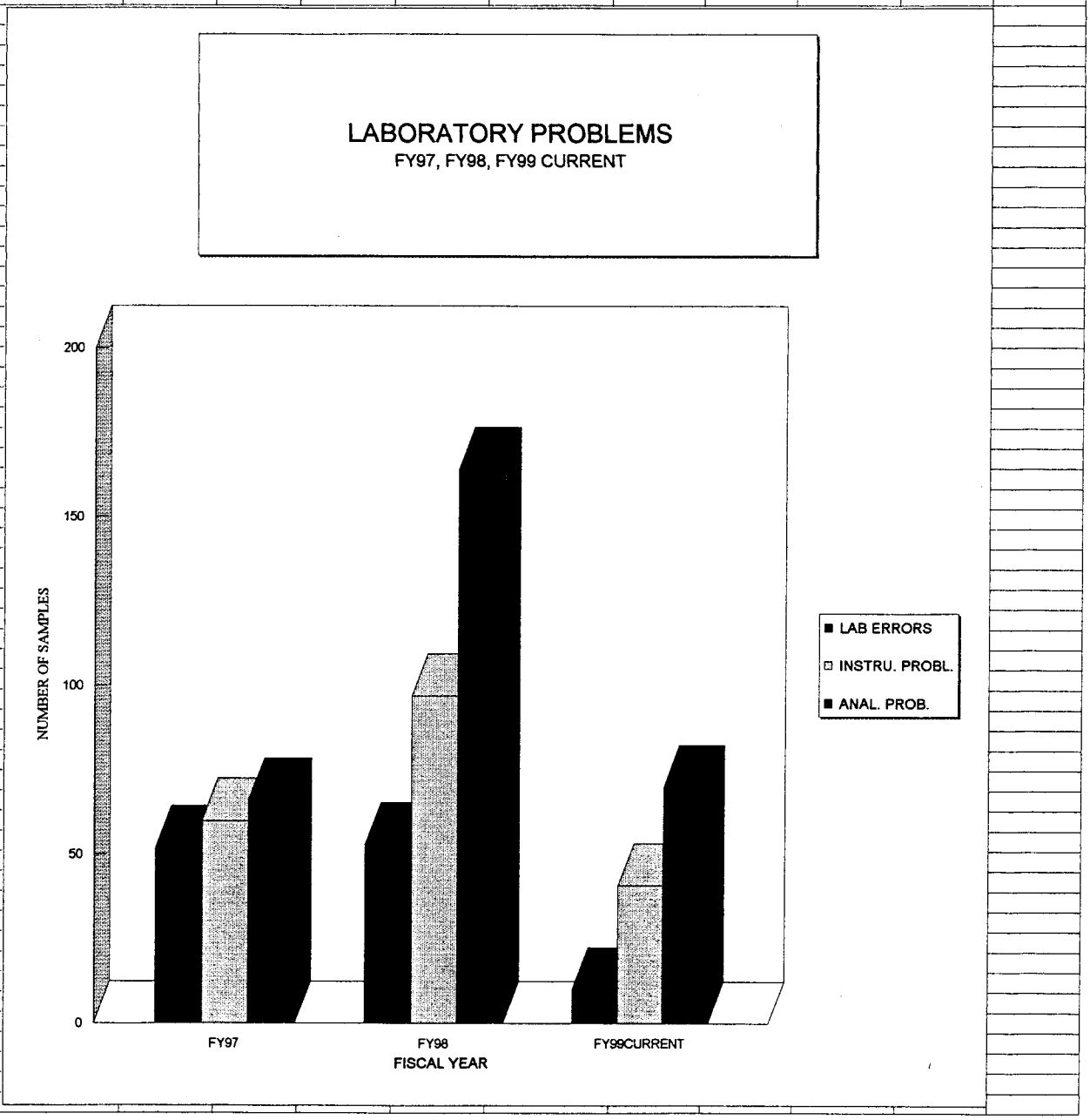
APPENDIX D

LABORATORY PROBLEMS EXPERIENCED

LABORATORY		LAB ERRORS			INSTRUMENT PROBLEMS			ANALYTICAL PROBLEMS		
		FY97	FY98	FY99	FY97	FY98	FY99	FY97	FY98	FY99
FLORENCE		9	9	1	0	0	0	26	25	6
AIKEN		27	10	0	0	0	0	25	18	3
LANCASTER		7	8	3	1	0	41	5	8	1
CHARLESTON		1	5	0	0	1	0	0	54	60
GREENVILLE		8	21	6	59	96	0	10	59	0
	TOTALS	52	53	10	60	97	41	66	164	70

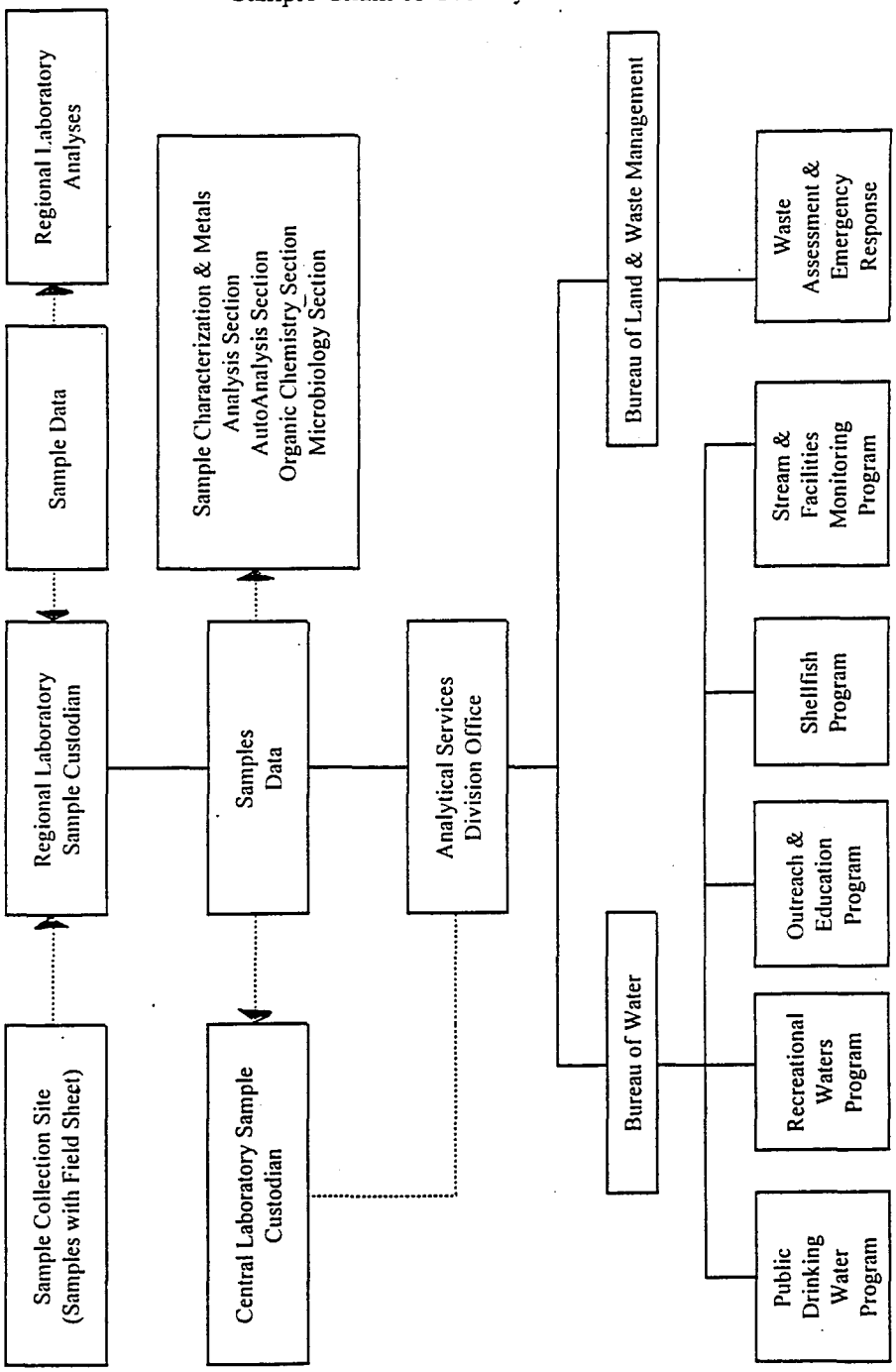
	FY97	FY98	FY99CURRENT
LAB ERRORS	52	53	10
INSTRUMENT PROBLEMS	60	97	41
ANALYTICAL PROBLEMS	66	164	70

NOTE: DATA FOR CHARLESTON LAB BEGAN IN JUNE'97 WHEN NEW CHEMIST WAS HIRED.



APPENDIX E

Figure IV-D-*1*
Analytical Services Division
Sample Chain of Custody and Data Flow



LABORATORY CUSTOMER BASE

APPENDIX F

TECHNICAL GUIDE
PROJECT PLAN

STEPS/ACTIVITY	NOV. 23 30	DEC. 7 14 21 28	JAN. 4 11 18 25	FEB. 1 8 15 22	MAR. 1 8 15 22 28	APR. 5 12 19 25
Contact ASD Director with implementation plans/goals	------					
Design input form for information and guide contents	------					
Send e-mail to analysts and lab mgrs. informing of the guide and solicit information w/deadines		------				
Contact lab mgrs./appointees to serve as reviewers of submittals from their staffs		-----				
Collect information		----------	----------	----------		
Establish review panel (ASD Dir. QA Mgr., Reg. Coordinator)		-----				
Order needed supplies: (binders, tabs, copy paper, etc.)			-----			
Remind analysts of deadline			-----			
Meet with Marci/Iva to coordinate typing/copying input material				------		
Begin compiling /organizing information received				-----		
Last call for information				-----		
Review content material with panel					-------	
Edit material					-------	
Type/copy guide content material						----------
Assemble guides						----
Distribute guides at Spring Lab Meeting In April'99						----

APPENDIX G

TECHNICAL GUIDE INPUT FORM

S.C.D.H.E.C. EQC- ASD AND REGIONAL LABS

ANALYST_____
LABORATORY_____

NAME OF PROCEDURE:_____
S.O.P. SECTION NUMBER:_____
Listed at top of procedure

PROBLEM/ TECHNICAL DIFFICULTY/QUESTION ENCOUNTERED:_____

SOLUTION/SUGGESTION TO ADDRESS PROBLEM:
*Solution Implemented*_____ *Suggestion Only*_____

PLEASE REFERENCE STEP/(STEPS) IN PROCEDURE WITH YOUR COMMENTS

Use Additional (Page/Pages) As Needed.